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Assessment of Suitability of Soil and Water Properties for Brackishwater Shrimp Farming–An Overview

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Abstract

Selection of potential and suitable site is the first and foremost step for successful aquaculture. Adequate water supply and its characteristics, soil quality and topography are the most important characteristics of a good site. The soil-water interface constitutes an important zone in the aquatic system where the shrimp lives most of the time. This zone of the aquaculture system regulates the success or failure of the crop. Researchers all over the world have emphasized the importance of soil and water properties for shrimp culture in improving the shrimp yield. Most of the studies show that the properties and culture to be followed are site specific and vary with places, site conditions. In India at many places along east coast similar studies have been carried out and the authors emphasized the importance of soil properties such as permeability, water holding capacity, pH, organic matter, texture for shrimp farming but very few studies have been carried out along the west coast. Considering the importance of soil and water quality parameters for shrimp farming, this paper reviews the important studies under taken along the coast of India. Further it also enlightens the importance of physico-chemical characteristics of the soil and water to check their suitability for brackishwater aquaculture.

Key words : Suitability, Soil and water properties, Brackishwater, Shrimp farming.

India has a coast line of 8,129 km which is distributed among nine coastal states from Gujarat in the northwest to Kerala and Tamil Nadu in the south to West Bengal in the northeast. Indian fishery is an important component of the global fisheries. During early nineties, shrimp aquaculture was developed rapidly in the east coast states of Andhra Pradesh, Orissa and Tamil Nadu and later in the west coast states. Karnataka has a coastal line of 300 km which is distributed among three districts namely Dakshina Kannada, Udupi and Uttara Kannada. Brackishwater aquaculture in India is essentially comprised shrimp culture in an age-old manner of farming in low-lying tidal areas. The ever increasing demand for shrimp and its products in the international market has resulted into over-exploitation of shrimp from natural sources. Although the resources are over-exploited, still there exists a large gap between the demand and supply of shrimp. This has necessitated the need for exploring new avenues for increasing shrimp production. In recent years, aquaculture has been attracting heavy investment due to the availability of sound technologies and limitless potential for export especially shrimp. Due to high profit, economic viability of the industry, low labour requirement, suitable soil and environmental conditions and encouraging market for products, aquaculture industry has expended in very short duration and is probably the fastest growing food industry in the world.

The aquafarming activities were initially started in the coastal fallow lands close to the estuarine and creeks. But due to the ever increasing demand for shrimps in the international market, people were tempted to increase the shrimp farming activities which gradually moved towards interior and neighboring paddy fields, salt pans, tidal and inter tidal mud flats and mangrove areas. The basic requirements of coastal aquaculture farm are ponds, water distribution structures and good soil and water quality parameters. Traditionally aquaculture ponds are earthen ponds, constructed in areas where the soil has sufficient clay content to prevent leakage of water (1). But in recent past, more and more areas are brought under brackishwater aquaculture and more people are engaged in the shrimp farming. With the advent of scientific shrimp farming, the tide-fed tradi-

tional culture was changed to pump-fed extensive and semi-intensive systems of farming in the elevated areas. Such shifting of the systems resulted in shrimp farms being located near agricultural lands in near by villages.

The fast growth of the shrimp farming industry has resulted in the indiscriminate development of shrimp farms without proper site selection and environmental impact assessment studies. As a result of this, the industry witnessed a major setback in coastal aquaculture due to disease out breaks all along the Indian coast. The disease out break was mainly due to the unplanned and mushroom growth of aquaculture farms (2). Proper designing of aquafarms is important for better management and there by to over come and/or minimize the adverse impacts on environment and aquaculture. But, most of the existing farms are not constructed as per technical designs or standards and there are many deficiencies in designs, construction and management of farms (3). As a consequence, majority of the farms constructed are not stable to withstand the hazards encountered in coastal region (4).

Site Selection

Selection of suitable site plays an important role since it helpful for proper planning, design, construction, operation and maintenance of ponds. A wrong site selection may result into higher cost of construction, culture operation and maintenance, and also affect the environment. Selection of suitable site strongly influences the ultimate success of the aquaculture enterprise. A suitable site is the one that provides optimum conditions for the growth of the species cultured at the targeted production level. Engineering aspects of farm design is relatively neglected and in most cases ponds are constructed with past experiences gained in the field. Interaction between soil and water that influence water quality in ponds must not be ignored, because poor soil condition in ponds can impair survival and growth of aquaculture species. A large amount of information is needed for proper planning; design and construction of aquaculture ponds, and often, project are developed without thorough evaluation of all pertinent factors. Some time, lack of attention to soil properties, water supply and quality, results in aquaculture ponds can not be used to their full potential. Some of the problems that are encountered in the maintenance of pond soil and water quality in brackishwater shrimp farming are related mainly to site characteristics. The single major phenomenon which differentiates a fish pond soil from an upland one is the presence of a layer of standing water above the bottom soil. In order to maintain favorable conditions for the healthy growth of the aquatic habitat, the physical and chemical factors must be studied, monitored and if required must be controlled. Important physical factors of water which affect the productivity are temperature, turbidity, color, odour etc. The chemical factors which have major influence on the production are pH, dissolved gases like oxygen, carbon dioxide and reducing gases like hydrogen sulphide and methane.

Soil Properties

Aquaculture ponds are normally built of soils. The properties of soil should be considered in selecting a site, designing earth work and specifying construction methods to provide a water tight pond (5). In shrimp pond, bottom soil play an important role not only in influencing productivity, but also acts as a store house of nutrients, helps in organic mineralization process, adsorption and release of nutrients to water, provide shelter and food to bottom biota, influence water quality and hence the survival and growth of shrimp (6). The bottom soil is the reserve source of nutrient elements which through the activity of several groups of micro-organisms are released in soluble forms (7). The soil properties depend on the characteristics of the parent material from which it has been derived by the action of natural resources. The retention and release of water by soil is a direct functional arrangement of soil aggregates and their porosity (8).

The importance of soil texture in the production of the brackishwater fish ponds has been emphasized by Djajadiredja and Poernom (9). Hajek and Boyd (5) emphasized that the knowledge about the soil permeability of a particular site is essential in designing earth work and specifying construction methods to provide a water tight pond with stable levees and bottom slopes. Seepage from aquaculture ponds results in poor productivity of the fish farm due to nutrient loss and fluctuation in the water quality param-

eters and also it leads to salinisation of adjacent agricultural areas and drinking water resources. Ponds constructed with good design and materials prevent saline water from seeping out and contaminating fresh water resource and adjacent agricultural lands. Texture, bulk density, organic matter and specific gravity determine to a large extent the water retention by soil. Water holding capacity of a soil denotes the amount of water that can be retained by unit volume of soil. Soils with high water holding capacity to make feasible earthen pond construction and to prevent losses due to seepage in the ponds are desirable. This parameter should be attended carefully when a new site is brought under fish culture. The importance of organic matter in bottom soil of brackishwater ponds has been emphasized by many workers (10). A large accumulation of organic matter in pond soil increases oxygen demand and favors anaerobic conditions. The organic matter concentrations and microbial decomposition of organic matter decrease rapidly with depth within the uppermost layer, because fresh organic matter is continually settling onto the soil and mixing with the surface layer (11). Thus the oxygen demand of pond soil is likely to decrease with soil depth. The pH of the soil is one of the most impotant factors in maintaining pond productivity since it controls most of the chemical reactions in the pond environment. If the pH is too low (strongly acidic) this can reduce the availability of key nutrients in the water and results in lower pond yield. The changes in pH in pond soil and water have practical significance in the maintenance of proper nutritional condition of the pond, apart from affecting the physiological functions of the fish. Interpretations of soil analyses data for use in aquaculture are difficult, because few data are available on relation ship between some chemical and physical properties of soils and aquatic animal production (12). Acidic soils can cause low pH and total alkalinity in ponds, and unless lime is applied ponds may be unsuitable for aquaculture.

Water Properties

The pH is an index of the presence of metabolites, photosynthetic activity and the fertility of the pond water. Brackinhwater has many advantages, it works as a medium for shrimp culture and it contains a high concentration of nutrient salts and is perfectly buffered medium against abrupt changes in pH. Salinity is a single factor plays an important role in shrimp farming as it is responsible for many functions such as metabolism, growth, osmotic behavior, reproduction etc. Shrimps have an optimal range of salinity for survival and better growth depending on the species. If the salinity is allowed to exceed beyond the optimal limit, the shrimp refrain from taking normal food, get emaciated and become susceptible to disease. Sudden reduction in the salinity associated with the heavy rains results in heavy mortality. This parameter however, forms an essential component of water analysis in case of brackishwater aquaculture. Turbidity can be caused either by planktonic organisms or by suspended soil particles. The turbidity due to silt and clay particles is known as inorganic turbidity and can interfere with the penetration of light and by absorbing nutrients present in the water and in turn affects the growth of benthos. This causes uneasiness and stress to the shrimp leading to disease. Suspended caly particles may damage the gills of shrimps by clogging it. In some cases, oxygen deficiency has also been reported as a result of sudden increase in turbidity.

Dissolved oxygen is the most important and critical water quality parameters in fish farming because of its direct effect on the feed consumption and metabolism of shrimp. Prolonged exposure to low oxygen content causes low feed consumption which leads to slow growth and also the culture organisms become inactive and they become susceptible to disease. Further, many or even all organisms may die from lack of oxygen. Photosynthesis occurs most rapidly in the surface layer of water; dissolved oxygen concentration is more at top and decreases with depth. Hence it is advantageous to have shallow ponds (75 to 150 cm deep) for shrimp, because they dwell mainly at the bottom and low dissolved oxygen at the pond bottom would be harmful for them. Dissolved oxygen gets affected by many factors; important among them are the water temperature, respiration of plants and animals, and the level of organic matter. In tropical waters, dissolved oxygen level is normally low because of higher temperature. The water exchange is the best solution to prevent low dissolved oxygen problem in the pond water where aeration is not practiced (13). The stress induced by poor water quality may result in reduced growth rates. Water quality

analysis is an important tool in aquaculture pond management, because results of analyses indicate if water quality is suitable for aquacultural production or if the concentrations of certain variables are sub-optimal. Once water quality inadequacies are recognized, treatments may be applied to mitigate them.

Janssen et al. (14) conducted the experimental shrimp farming in ponds in Polekurru, Andhra Pradesh, India, to identify a suitable pond design, develop proper water management schedules and compare tide and pump fed ponds. He suggested that for the construction of tide fed ponds, the level of the pond should be determined on the basis of tidal data collected at the spot for a period of at least one year. Gupta et al. (15) conducted the experiments to find out the suitability of saline soils of Gopalapuram, Nellore for shrimp farming. It concludes that for soils which have low pH, high sand content and low organic carbon require species attention. This limitation can be overcome by special planning and management such as liming, organic manuring and additional compaction of soils.

Kaladharan et al. (16) conducted experiments to study soil and water charactristics in several small and large on-shore shrimp farms in nine coastal villages along the coast of Tamil Nadu and Pondicherry, India. In general, most of the parameters showed higher values within the ponds, while more or less uniform values were observed in the inlets and out lets, in water and in soil, except the alkalinity in water and pH in soil. Jayanthi et al. (17) conducted the experiments to assess the soil water holding capacity and other related properties suited to aquaculture ponds in coastal saline belt. Comparing soil properties of all the sites, it was found that Kakinada soil was characterized by highest water holding capacity, associated with the higher values of liquid limit, porosity and clay content, and concluded that soil of Kakinada are best suited for the construction of aquaculture ponds. The Nellore and Muttukadu soils had less water holding capacity because of their sandy nature. Nila Rekha et al. (18) conducted the experiments to test the soil properties of Nellore (Andhra Pradesh), Kokilamedu, Tiruporur and Muttukadu (Tamil Nadu) and determined soil permeability, texture, bulk density, organic carbon and water holding capacity. The permeability of soil at Muttukadu was high and it was least at Thiruporur. It was also observed that average clay content was low in Muttukadu soil and more in the Thiruporur soil and suitable management practices were adopted in sandy loam and clay soil of these places.

Joseph et al. (19) conducted experiments to study the soil and water conditions of coastal regions during shrimp farming. It was observed that the best method for preventing soil and water quality problems in aquaculture pond environment is to select a site with good soil, adequate supply of good quality water and maintaining moderate levels of shrimp production. Sachidanandamurthy and Yajurvedy conducted the study on physico-chemical parameters of a lake in Mysore city to assess its suitability for pisciculture. It was noticed that some of the water quality parameters such as temperature, total suspended solids, dissolved oxygen, nitrite and ammonia were within the desired limit. On the other hand total alkalinity and hydrogen sulphide through out the study period and pH for a major part were higher than desirable limit. Other properties viz., turbidity, biological oxygen demand, phosphate and nitrate in few months were higher than the desirable limit required for fish culture. Hajek and Boyd (5) have some guidelines which provide an aid in site selection and design of aquaculture ponds. Guidelines have been developed for evaluating available land classification, soil survey and soil property reports for applicability to planning and developing aquaculture uses of land. Rating guides also were prepared for the quantity and quality of source of water for aquaculture ponds. Tekwa et al. conducted field survey at six locations to assess the suitability of some soils for fresh water fish farming in Madagali, LGA of Adamawa state. Site characteristics such as present land use, vegetation and topography, and soil parameters such as texture, pH, organic matter, bulk density, porosity and permeability were studied using standard procedure. It was concluded that soil is suitable for fresh water fish farming.

The study conducted by many scientists along the east coast concluded that special planning and management such as liming, organic manuring and additional compaction of soils improved some of the soil properties. Suitable precautions while constructing the ponds on the bed of sandy loam and sandy soil prevented seepage of water. It has been reported that more effective planning and monitoring reduced

the impact of shrimp farming on adjacent soil and water.

Conclusion

The environmental and disease problems faced by the shrimp culturists are mainly due to poor site selection, inappropriate design of shrimp farms and improper planning. Many authors emphasized the importance of the soil and water properties in the selection of suitable site and in determining the productivity of brackishwater aquaculture systems. Considering the importance of soil and water quality parameters for shrimp farming this paper reviews the important studies under taken along the east coast of India. Further it also enlightens the importance of physico-chemical characteristics of the soil and water to check their suitability for brackishwater aquaculture.

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